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GEOSITE EVALUATION; CAN WE MEASURE INTANGIBLE VALUES?

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ABSTRACT: V.M. Bruschi & A. Cendrero, *Geosite evaluation; can we measure intangible values?* (IT ISSN 0394-3356, 2005).
A discussion on issues to be addressed in the process of cataloguing and assessing geosites is presented. Different stages of the process are considered: identification, classification, inventory, evaluation, protection and use. Inventories to be elaborated should be satisfactory from different points of view: scientific quality of sites, definition of protection levels, possibility of educational or recreational use, or potential for generating economic activities.
A problem that permeates all stages of the process is subjectivity. Establishment of ranks of scientific interest for sites in a region, proposals for protection measures or drafting plans for the use of geosites cannot be based exclusively on scientific, objective criteria. Subjectivity is an unavoidable (perhaps even desirable) part of all of them. This represents an important difficulty because if protection and use plans for geosites are to be successful, they should be based on transparent criteria that can be subject to external, independent scrutiny and evaluation. This should include some sort of validation to determine to what extent classifications and proposals presented reflect social values, be they expressed by specific stakeholder groups (earth scientists, decision makers, elected officials, conservationists) or general public. If those values are well reflected plans will be socially acceptable and more likely to be useful.
An approach is presented based on the definition of three groups of criteria, related to: a) intrinsic quality of sites; b) potential threats and protection needs; c) potential for use. Indicators are presented for each criterion. Particular efforts have been made to propose indicators that can be expressed by means of continuous variables. When this has not been possible categorical, "objective" variables are used. Combination of those indicators into different types of indices can be used as a means to "measure" the type of intangible qualities mentioned above. The advantage of the approach proposed is that numerical classifications of sites obtained using that kind of "quality models", can be validated through comparison with independent external opinions or evidences.
Two applications to case studies for cataloguing and assessing are presented. The first one concerns the assessment of geosites using clearly-stated criteria based on observable characteristics. The methodology is applied to an existing geosites inventory; validation is carried out by comparison with a very much appreciated geomorphic landmark in the same region as well as with expenditure on two sites subject to restoration.
The second case study refers to the identification and ranking of geosites for a new inventory. Ranks obtained directly from surveys among geomorphologists are compared with those derived from the application of the method. The analyses presented indicate that the "quality models" used yield results that coincide quite well with independent assessments or evidences for "clearly good quality sites". Agreement is less satisfactory for sites lower down in the ranks. Some inconsistencies between direct subjective assessment by individual experts and systematic assessment based on quality criteria proposed by the same expert have also been found. It is concluded that the method in its present form provides a satisfactory "coarse grain" image of sites' quality but improvements are needed.

RIASSUNTO: V.M. Bruschi & A. Cendrero, La valutazione dei geositi: possiamo misurare valori intangibili? *(IT ISSN 0394-3356, 2005).*
Nel presente lavoro si tratteranno i principali aspetti relativi al procedimento della catalogazione e della valutazione dei "geositi" e, più in concreto, si tratteranno i diversi stadi del procedimento generale quali, la identificazione, la classificazione, l'inventario, la valutazione, la protezione e l'uso. Gli inventari dei geositi devono esssere elaborati in modo soddisfacente dal punto di vista della qualità scientifica dei beni geologici, della definizione dei diversi livelli di protezione, dei possibili usi educativi e ricreativi e dal punto di vista del potenziale per lo sviluppo di attività economiche. Uno dei principali problemi che interessano il trattamento dei "geositi" e i differenti stadi dell'analisi è la soggettività. La determinazione del grado d'interesse scientifico proprio dei beni geologici di una regione, le proposte relative alle misure di protezione o all'uso potenziale dei sopracitati beni non possono essere elaborate unicamente con criteri scientifici o obbiettivi; la soggettività deve essere considerata parte inevitabile del procedimento generale. Ciò rappresenta una difficoltà importante dato che, per ottenere una protezione ed un uso soddisfacenti dei geositi, è necessario basare gli studi su criteri trasparenti e che possano essere soggetti a valutazioni e giudizi esterni ed indipendenti. Ciò implica la necessità di una valutazione che permetta definire fino a che punto le classificazioni e proposte elaborate riflettono l'opinione pubblica, sia per quanto riguarda gruppi d'esperti che per quanto riguarda un pubblico più ampio. L'unica forma per rendere efficaci ed utili le proposte eleborate per il trattamento dei geositi, è che queste ultime riflettano in modo adeguato l'opinione pubblica. La metodologia che si presenta a continuazione si basa sui tre seguenti pricipali gruppi di criteri quali, la qualità intrinseca dei geositi, le potenziali minacce e necessità di protezione ed il potenziale d'uso, per ognuno dei quali si propongono degli indicatori di misura. É stato prestato un particolare sforzo nel proporre indicatori che possano essere rappresentati con variabili continue, quando non è stato possibile, si è passati a variabili categoriche cercando sempre di mantere l'oggettività dell'analisi. Per misurare le qualità descritte anteriormente applicando i relativi modelli di qualità e valutazione, sono state utilizzate varie combinazioni degli indicatori attraverso l'applicazione di indici numerici. Il principale vantaggio di questa metodologia risiede nella possibilità di comprovare i risultati e, di conseguenza, il metodo stesso, attraverso opinioni esterne ed indipendenti. Il modello iniziale può esssere perfezionato fino ad ottenere una buona corrispondenza con le valutazioni effettuate da chi è preposto a decidere. Si presentano due applicazioni relative al processo di catalogazione e di valutazione dei geositi. La prima si riferesce alla valutazione dei geositi attraverso l'uso di criteri definiti basandosi su caratteristiche oggettive e osservabili. La metodologia viene applicata a un inventario di geositi esistente, la validazione del metodo è stata ottenuta attraverso la comparazione con i risultati derivanti dalla valutazione di un geosito, il cui interesse è ampiamente riconosciuto ed accettato nella regione, e di altri due beni soggetti a ripristino e situati in due regioni limitrofe alla zona oggetto dello studio. La seconda applicazione si riferisce alla identificazione e categorizzazione dei geositi per la elaborazione di un nuovo catalogo. La categorizzazione, ottenuta attraverso un sondaggio sottoposto a geomorfologi, è stata confrontata con il "medello di qualità" constatando che i risultati ottenuti dai due metodi (modello di qualità e valutazione indipendente) coincidono abbastanza, soprattutto per quanto riguarda i beni di qualità elevata. Per i geositi ritenuti di qualità inferiore, la coincidenza fra i due metodi è decisamente inferiore. Inoltre è stato evidenziato un certo disaccordo fra la valutazione dei geositi soggettiva realizzata dagli esperti e la valutazione sistematica elaborata sulla base di criteri di qualità proposti dagli esperti stessi. Per concludere, nonstante sia necessario apportare miglioramenti, il metodo presentato rispecchia in modo soddisfacente la valutazione dei geositi di buona qualità.

Keywords: Geosites, Cataloguing, Evaluation, Intangible values, Quality indicators, Validation, Spain.

Parole chiave: Geositi, Catalogazione, Valutazione, Valori intangibili, Indicatori di qualità, Validazione, Spagna.

1. INTRODUCTION

Identification, cataloguing and evaluation of geosites is a complex task that stands somewhere between scientific analysis and evaluation of historical, artistic or cultural heritage. This implies the need to combine very different criteria, approaches and, in particular, disciplinary cultural backgrounds. In the process of inventorying and assessing geosites it is necessary to combine scientific criteria with other criteria related to intangible values (Panizza & Piacente, 1999; Poli, 1999) more commonly associated with artistic or historical objects. Such values include, for instance, "quality of the natural heritage", "cultural or educational interest" (Reynard *et al*., 2002), "tourism and recreation potential" or "protection need" (Cendrero, 2000).

The different tasks to be performed require, on the one hand, data collection and scientific interpretation; that is, activities normally associated with the "objective" natural or experimental sciences. On the other hand, it is necessary to make value judgements, much more common in the subjective realm of artistic object's assessment.

In a scientific environment as the Earth Sciences it is normally expected that opinions (scientific interpretations) are based on transparent criteria that can be subject to external, independent scrutiny and evaluation. This should include the possibility to replicate, by any operator, results obtained by another one. It is therefore convenient to design and test procedures for cataloguing and evaluation that are based on clearly-stated criteria and, as far as possible, quantitative parameters. Such criteria and parameters could be used to derive numerical indices obtained through well defined steps and methods (Mohr, 1988).

The use of that type of approach can help to "validate" the method; that is to determine to what extent assessments by a group of experts are coincident with those by other experts in the discipline. It is also desirable to "validate" what we could name "scientific consensus" against the perception by other stakeholder groups such as experts from other disciplines, decision makers, elected officials, conservationists or general public. If the method, criteria and procedure used yield results that reflect reasonably well social values and interests, the final aim of promoting careful use and conservation of geosites is more likely to be achieved.

A series of stages can be identified in the general process that starts with the identification of valuable geosites and leads to their protection and use. Those stages are: a) Site identification; b) Inventory and classification; c) Evaluation; d) Protection; e) Use. It is important to bear in mind that the first three stages should not be the aim of this type of undertaking; they are simply means to achieve the final goal indicated above: conservation and use. It follows that inventories of geosites in general and geomorphosites in particular should be satisfactory from a variety of viewpoints. Those include, obviously, quality of sites, but also usefulness for defining protection levels, carrying out educational or recreational activities, or potential to generate economic activities (Martini, 2000). That is, establishment of value ranks for geosites within a region, proposals for protection measures or plans for their use should not be based exclusively on scientific criteria. If those proposal and plans are to be successful they should be accepted by local society.

Comparison with what has happened in many countries with respect to conservation or rehabilitation of historical and artistic heritage provides some interesting lessons. There are many examples of badly deteriorated historical buildings whose restoration and protection was achieved only when they were dedicated to purposes perceived as "useful" by society as a whole (administration or education buildings, hotels and restaurants, museums, etc). This is more difficult in the case of geosites, but it is probably worth making efforts to promote their "social usefulness", other than the obvious preservation of a part of natural heritage.

In what follows below some proposals are presented towards the establishment of systematic procedures for geosite identification, cataloguing and assessment, that try to minimise the problem of subjectivity and, at the same time, help to define protection and development actions.

2. PROPOSED PROCEDURE

Accepting that subjectivity (based on expert's opinion) is an unavoidable part of the overall inventory and assessment process, the procedure presented is based on the definition of a series of successive steps that facilitate the establishment of clearly-stated criteria. Those steps are:

- Identification of significant criteria ("qualities" of geosites)
- Definition of indicators to "measure" each criterion
- Establishment of value ranks for individual indicators
- Establishment of procedure for the integration of individual qualities (formulation of a "value model")
- Validation

Probably the most important step in the process is the identification of suitable indicators for ranking sites according to the different qualities considered. Ideally all such indicators should be based on the use of continuous variables, but this will not always be possible. Another important, but difficult, step is validation. Contrary to models normally used in geomorphology, that try to represent physical processes, "value models" used in geosite's assessment try to reflect opinions, be they from experts, other stakeholders groups or general public. In the case of physical models validation can easily be performed by comparing model-predicted and actual process behaviour. Validation of "quality or value models" rests on a somewhat more shaky ground; probably the simplest form of validation is comparison between assessment by a study team and those of external expert teams or different social groups.

The procedure proposed starts with the identification of a series of criteria that can be grouped into three main categories (Cendrero, 2000):

a) Intrinsic quality of sites (scientific merit)
- Abundance/rarity
- Degree of scientific knowledge
- Usefulness as process model/example

- Diversity of elements of interest
- Age
- Type locality
- Association with historical, archaeological, artistic heritage
- Association with other natural heritage
- State of conservation

b) Potential for use (social usefulness)
- Activities that can be carried out
- Observation conditions
- Accessibility
- Extent
- Proximity to service centres
- Socio-economic condition of the area

c) Potential threats and protection needs (urgency to act)
- Inhabitants in the surroundings
- Present or potential threats
- Possibility to collect objects
- Relationship to existing planning
- Interest for mineral exploitation
- Land ownership

Indicators that can be used to "measure" those criteria are shown in Tables 1, 2 and 3. For each indica-

Tab. 1 - Indicators and ranks for criteria related to intrinsic quality. Capital symbols in brackets correspond to the ones used for Qi calculation in expression [1]. Indicators for which only three levels could be defined are marked with an asterisk (*).

Indicatori e ranghi definiti per il criterio relativo alla qualità intrinseca. In maiuscolo e fra parentesi i simboli corrispondenti agli indicatori usati per il calcolodella Qi secondo l'espressione matematica corrispondente [1]. Gli indicatori per i quali è stato possibile definire solo tre ranghi vengono segnalati con un asterisco (*).

INTRINSIC QUALITY		
Indicators	**Ranks**	
Abundance/rarity (A)	4	Only one example in the region
	3	2-4 examples
	2	5-10 examples
	1	11-20 examples
	0	>20 examples
Degree of scientific knowledge (K)	4	More than 1 Ph.D. Thesis; several papers in international/national journals
	3	1 Ph.D.Thesis; at least 1 international or several national papers
	2	1 national paper
	1	Some notes in national journals or articles in regional/local journals
	0	No publications
(*) Usefulness as process model/example (Ex)	4	Present, active process clearly visible/interpretable
	2	Erosion/deposition features of present processes not clearly defined
	0	Fossil forms and/or deposits whose use for interpretation of past processes is difficult
Diversity of elements (geomorphic, stratigraphic, paleontologic, etc) (D)	4	5 or more elements
	3	4 elements
	2	3 elements
	1	2 elements
	0	Only 1 element
Age (difficult, disputable criterion; it can be accepted that "other factors being equal", the older the better) (Ag)	4	Mesozoic or older
	3	Cenozoic
	2	Lower Pleistocene
	1	Upper Pleistocene
	0	Holocene
(*) Type locality? (T)	4	Formally recognised type locality
	2	Secondary or reference type locality
	0	Not proposed as type locality
Association with historical, archaeological, artistic heritage (Ch)	4	Presence of archaeological and several types of other elements
	3	Archaeological and one additional type of element
	2	Archaeological remains
	1	Other, non-archaeological elements
	0	No additional elements
(*) Association with other natural heritage (N)	4	Outstanding landscape and valuable flora and fauna
	2	Outstanding landscape or valuable flora/fauna
	0	Valuable landscape
State of conservation (C)	4	Well preserved; no degradation
	3	Damage to minor characteristics
	2	Partially affected by human activities, but character of site remains
	1	Very affected by human activities; many characteristics degraded
	0	Intense degradation; loss of the site's character

Tab. 2 - Indicators and ranks for criteria related to potential for use. Capital symbols in brackets correspond to ones used for Ui calculation in expression [1]. Indicators for which only three levels could be defined are marked with an asterisk (*).

Indicatori e ranghi definiti per il criterio relativo al potenziale d'uso. In maiuscolo e fra parentesi i simboli corrispondenti agli indicatori usati per il calcolo della Ui secondo l'espressione matematica corrispondente [1]. Gli indicatori per i quali è stato possibile definire solo tre ranghi vengono segnalati con un asterisco (*).

POTENTIAL FOR USE		
Indicators	**Ranks**	
Activities that can be carried out (scientific, educational, tourism, recreation, object collecting, etc.) (Act)	4	5 or more activities
	3	4 activities
	2	3 activities
	1	2 activities
	0	1 activity
(*) Observation conditions (O)	4	No limitations for entry; no visual obstructions
	2	Some physical limitations for access and/or viewing
	0	Physical difficulties for access and views obstructed by constructions vegetation, etc.
Accessibility (Acc)	4	Direct access through main road
	3	Access through local roads
	2	Access through unpaved roads or tracks
	1	No road access but < 1 km from the nearest one
	0	> 1 km from the nearest raod access
Extent (m^2) (E)	4	$> 10^6$
	3	$10^5 - 10^6$
	2	$10^4 - 10^5$
	1	$10^3 - 10^4$
	0	$< 10^3$
Proximity to service centres (S)	4	Centre > 10,000 inhabitants and diversity of lodging and catering facilities within 5 km
	3	Locality > 10,000 inhabitants and some facilities within 5 km
	2	5 – 20 km to lodging/catering facilities
	1	20 – 40 km
	0	> 40 km
(*) Socio-economic condition of the area (SE)	4	Per capita income and education > 15% above national average
	2	National average
	0	> 15% below national average

tor a five-term (0 – 4) rank has been established. Thus, indicators initially expressed by means of different, heterogeneous units are transformed into homogeneous categorical units.

The following expression provides a "quality model" that can be applied to geosites using indicators presented above.

$$V_{SGI} = (Qi+Ui+Pi)/3 \qquad [1]$$

Where: V_{SGI} = value or merit of geosite (0-1); Qi = intrinsic quality (0-1); Ui = potential for use (0-1); Pi = protection need (0-1).

$$Qi = (A\times Wa + K\times Wk + Ex\times Wex + D\times Wd + Ag\times Wag + T\times Wt + Ch\times Wch + N\times\_Wn + C\times Wc) / 4$$

$$Ui = (Act\times Wact + O\times Wo + Acc\times Wacc + E\times We + S\times Ws + SE\times Wse) / 4$$

$$Pi = (I\times Wi + T\times Wt + CO\times Wco + P\times Wp + M\times Wm + L\times Wl) / 4$$

Wi = weight of each indicator ($\Sigma Wi=1$).

The meaning of variables in the expression above is shown in Tables 1, 2 and 3.

Of course, other "quality models" can be considered, such as:

$$V_{SGI} = Ci\ (2Qi+Pi)/12 \qquad [2]$$

Where: Ci = degree of conservation of geosites (0-4); Qi = intrinsic quality of geosites (0-1); Pi = potential for use of geosites (0-1).

Models assume that if a site ranks high with respect to the three qualities considered (scientific merit, social usefulness, urgency to act) can be considered as very valuable and should be included in inventories and protection plans. Indicators and models proposed provide a means to express those intangible qualities by means of numerical indices, using transparent models that yield replicable results. The use of such indices should facilitate the incorporation of geosites into a variety of assessments for environmental decision making.

3. APPLICATION TO CASE STUDIES

The concepts and general procedure described above have been applied to two case studies, in order to test the validity of the method proposed.

Tab. 3 - Indicators and ranks for criteria related to potential threats and protection needs. Capital symbols in brackets correspond to ones used for Pi calculation in expression [1]. Indicators for which only three levels could be defined are marked with an asterisk (*).

Indicatori e ranghi definiti per i criteri relativi alle potenziali minacce e alle necessità di protezione. In maiuscolo e fra parentesi i simboli corrispondenti agli indicatori usati per il calcolo della Pi secondo l'espressione matematica corrispondente [1]. Gli indicatori per i quali è stato possibile definire solo tre ranghi vengono segnalati con un asterisco (*).

POTENTIAL THREATS AND PROTECTION NEEDS		
Indicators	**Ranks**	
Inhabitants in the surrounding (within a 25 km radius) (I)	4	> 100,000
	3	50,000 – 100,000
	2	25,000 – 50,000
	1	10,000 – 25,000
	0	< 10,000
(*) Present or potential threats (T)	4	Area with clear urban-industrial development or projects for new infrastructures
	2	Intermediate area; no immediate development projects but clear expectations for the near future
	0	Rural area; no expectations of urban-industrial-infrastructure development in the foreseeable future
(*) Possibility to collect objects (CO)	4	Fossil, mineral or rock samples can be collected and site damaged
	2	Objects can be collected without major damage to the site
	0	No possibility to collect objects
Relationship to existing planning (P)	4	Area classified for urban, industrial or service uses
	3	No existing plans
	2	Site not protected but in area classified as rural in existing plans
	1	Site in area with some protection status in local/provincial plans
	0	Included within national park or other nationally protected space
Interest for mineral exploitation (M)	4	High mineral interest and current mining permits in the area
	3	Area with reserves of low-unitary value resources and where quarrying is currently allowed
	2	Area with reserves of low-unitary value resources but where quarrying is not currently allowed
	1	Some indications of mineral resources
	0	No mining interest
(*) Land ownership (L)	4	Site located in private land
	2	Both public and private property
	0	Public property

3.1 Geosites evaluation within the EIA process.

One case study deals with the evaluation of an existing inventory of geosites in an area of northern Spain (Fig. 1), as part of the EIA process for a new motorway (Bonachea *et al*., 2003). The procedure described here is an improvement of a former proposal; a more detailed description can be found in Rivas *et al*. (1997). The inventory used is shown in Figure 2.

The value of each geosite was defined using a "quality model" slightly different to the ones presented above [1, 2].

$$V_{SGI} = Ci\,(2Qi + Pi) / 48 \qquad [3]$$

Where: Ci = degree of preservation (0 – 4); Qi = intrinsic quality (0 – 4); Pi= potential for use (0 – 4); VSGI = value of site (0-1)

Quality (Q) was defined as: $Qi = WA \times A + W_E \times E + W_K \times K + W_{Ex} \times Ex + W_D \times D$

Where:

A: relative abundance of the site's type;
D: diversity of geological/geomorphological elements;
E: extent of the site;
Ex: value of site as example of geomorphological processes;
K: degree of knowledge about site.
W: weights of the factors considered; $\Sigma W = 1$

Potential for use (P) was obtained using a similar expression:

$$Pi = WAc \times Ac + W_O \times O + W_S \times S + W_H \times H + W_{Acc} \times Acc$$

Where:

Fig. 1 - Location map.
Inquadramento geografico dell'area.

Ac: types of activities that can be carried out on site;
O: observation conditions;
S: availability of services;
H: number of inhabitants in surrounding area
Acc: accessibility;
W: weights of factors considered; Σ W = 1.

Table 4 shows the indicators and ranks (0 – 4 scale) established for the different parameters used to calculate the value of geosites (Bonachea *et al.*, 2003). Table 5 presents, for all geosites analysed, values of the different factors considered as well as those for C, Q, P and V_{SGI}.

To validate those results comparison with well-known and socially appreciated geomorphologic landmarks in the region was made. Geosites chosen as standards for comparison are the “Ratón de Guetaria” (Guetaria Mouse; Fig. 3), probably the best known and most appreciated geomorphic landmark in the province of Guipúzcoa, and two sites subject to restoration, one in Vizcaya and one in Cantabria (Fig. 1). Values obtained for those geosites using the same procedure are:

Ratón de Guetaria (Fig. 3): V_{SGI} = 0.86
Coastal area of Somorrostro: V_{SGI} = 0.5
Karst of Cabárceno (Fig. 4): V_{SGI} = 0.9

Expenditure on restoration for the latter two sites was respectively 3 $\times 10^6$ € and 12 $\times 10^6$ € (restoration actions also included non-geomorphic elements). Both the “Ratón de Guetaria” and “Karst of Cabárceno” are widely known and very much appreciated by local population. The “coastal area of Somorrostro”, on the other hand, is less known and not so much valued. That is, informal, subjective perception by local population is coherent with numerical values obtained using the procedure described. Moreover, if effort devoted to restoration is used as an additional external indicator of “social appreciation”, we can see that expenditure in Cabárceno (V_{SGI} = 0.9) was considerably higher than in Somorrostro (V_{SGI} = 0.5). This is also reasonably coherent with the systematic evaluation described, although by no means should be considered as an objective measure of the sites’ value, due to the different cost factors involved in restoration.

Comparison between V_{SGI} and actual expenditure on restoration provides the basis for a rough translation of the intangible “geosite value” into monetary units. From the figures provided above an average “theoretical value” of about 10 $\times 10^6$ € can be assumed for an ideal site with V_{SGI} = 1. This can in turn be used to express impact on geomorphosites or geosites in general, using reductions or increases in the dimensionless V_{SGI} as well as the “theoretical monetary loss or gain” implied (Bonachea *et al.*, 2003). An example of this is shown in Table 5. If monetary values indicated above are accepted, “theoretical losses” would be 3.7 $\times 10^6$ € and 8.9 $\times 10^6$ € for alternatives A and B respectively.

In brief, although criteria used to obtain VSGI will not necessarily be accepted by everyone and indicators used for “external validation” of the process have a certain degree of uncertainty, it appears that the procedure proposed represents a useful means to obtain, at least, a “coarse-grain” image of the quality of geomorphosites.

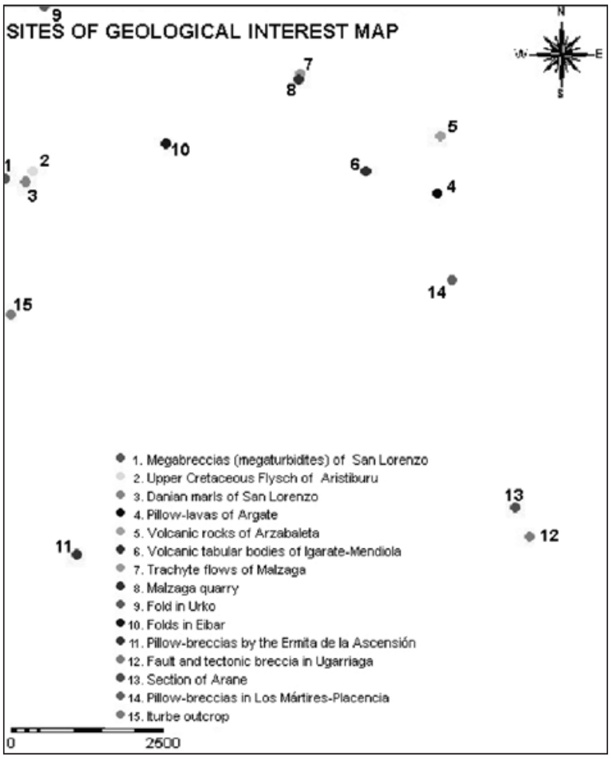

Fig. 2 - Distribution of geosites in the study area for the Vergara-Eibar motorway sector.

Distribuzione dei punti d’interesse geologico nella zona interessata dal tratto d’autostrada Vergara-Eibar.

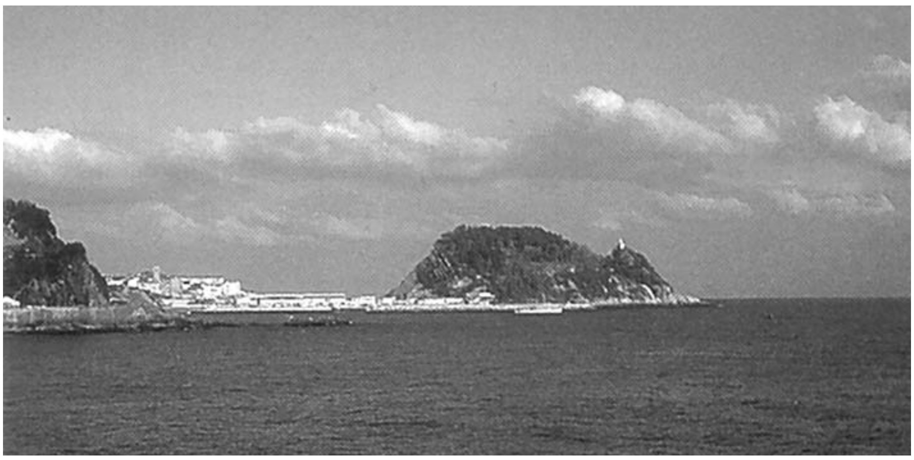

Fig. 3 - The “Ratón de Guetaria” (Guetaria Mouse), prominent geomorphological landmark in the region.

Il “Ratón de Guetaria” (Topo di Guetaria), punto d’interesse geomorfologico significativo della regione.

Tab. 4 - Indicators and ranks for the value of each geosite (expression [3]; Bonachea *et al.*, 2003). Indicators for which only three levels could be defined are marked with an asterisk (*).

Indicatori e ranghi definiti per il calcolo del valore definitivo di ogni punto d'interesse geomorfologico (espressione matematica [3]; Bonachea et al.*, 2003). Gli indicatori per i quali è stato possibile definire solo tre ranghi vengono segnalati con un asterisco (*).*

CRITERIA	Indicators	Rank	
DEGREE OF PRESERVATION (C)	**Degree of preservation**	4	Well preserved; no visible degradation
		3	Some degradation; damage to minor characteristics
		2	Part of its characteristics degraded
		1	Very affected by human activities, many of its characteristics degraded
		0	Total degradation; loss of the site's character
INTRINSIC QUALITY (Q)	**Relative abundance of the site's type (A)**	4	Only one example in the region
		3	2 – 4 examples
		2	5 - 10 examples
		1	10 - 20 examples
		0	> 20 examples
	Diversity of geological/ geomorphological elements (D)	4	5 or more
		3	4
		2	3
		1	2
		0	Only 1
	Extent of the site (E)	4	> 90% of the greatest SGI of the same kind
		3	70 – 90%
		2	30 – 70%
		1	10 – 30%
		0	< 10%
	(*)Value of site as example of geomorphological processes (Ex)	4	Present, active processes clearly defined
		2	Erosion/accumulation features of present processes not clearly defined
		0	Fossil forms and/or deposits whose use for extrapolation of past processes is difficult
	Degree of knowledge about site (K)	4	More than one Ph.D Thesis and numerous articles in refereed national and international journals
		3	At least one Ph.D Thesis and/or more than one article in refereed international journals and/or various in national journals
		2	Some articles in refereed national journals and/or one article in an international journal
		1	Some brief notes in national journals or some articles in regional-local journal
		0	No existing publications
POTENTIAL FOR USE (P)	**Types of activities that can be carried out on site (Ac)**	4	5 types of activities
		3	4 types of activities
		2	3 types of activities
		1	2 types of activities
		0	1 types of activities
	(*) Observation conditions (O)	4	Public property of land, no limitations of access, no visual obstructions
		2	Limitations of access or partial visual obstructions
		0	Private property or view obstructed by fences, vegetation, etc.
	Availability of services (S)	4	Good services within 4 km
		3	Good services within 45 km
		2	Incomplete services within 5 km
		1	Good services within 10 km
		0	Absence of services within 10 km
	Number of inhabitants in surrounding area (H)	4	> 100,000 inhab. in a radius of 25 km
		3	50 – 100,000 inhab. in a radius of 25 km
		2	25 - 50,000 inhab. in a radius of 25 km
		1	10 - 25,000 inhab. in a radius of 25 km
		0	< 10,000 inhab. in a radius of 25 km
	Accessibility (Acc)	4	Direct access via national/regional roads
		3	Direct access via local roads
		2	Direct access via tracks
		1	< 1 km from a vehicle path
		0	> 1 km from a vehicle path

Tab. 5 - Indicator values and V_{SGI} for geosites in the area of the Vergara-Eibar motorway sector. A: relative abundance; E: extent; K: degree of knowledge; Ex: good example of processes; D: diversity; Ac: activities; O: observation conditions; S: availability of services; H: number of inhabitants; Acc: accessibility; C: state of conservation; Q: quality SGI; P: potential for use; $V_{SGI\ (pre)}$: value of SGI before motorway construction, $V_{SGI\ (post\ A,\ B)}$: value of SGI after motorway construction (alternatives A and B).

Indicatori e V_{SGI} per i punti d'interesse geologico nelle zona interessata dal settore d'autostrada Vergara-Eibarna. A: abbondanza relativa; E: estensione; K: grado di conoscenza; Ex: buon esempio di processo; D: diversità; Ac: attività; O: condizioni d'osservazione; S: presenza di servizi; H: numero di abitanti; Acc: accessibilità; C: stato della conservazione; Q: qualità del punto d'interesse geologico; P: potenziale d'uso; $V_{SGI\ (pre)}$: valore del punto d'interesse geologico prima della costruzione dell'autostrada; $V_{SGI\ (post\ A,\ B)}$: valore del punto d'interesse geologico dopo la costruzione dell'autostrada (alternative A e B).

Nº. site	Name, SGI	A	E	K	Ex	D	Ac	O	S	H	Acc	C	Q	P	$V_{SGI\ (pre)}$	$V_{SGI\ (post\ A)}$	$V_{SGI\ (post\ B)}$
1	*Megaturbidites, San Lorenzo*	0.80	0.40	0.40	0.40	0.00	0.00	0.80	0.80	0.60	0.80	4.00	2.00	3.00	0.58	0.58	0.58
2	*Cretaceous Flysch, Aristiburu*	0.80	0.40	0.40	0.40	0.00	0.00	0.80	0.80	0.60	0.80	4.00	2.00	3.00	0.58	0.58	0.58
3	*Danian marls, San Lorenzo*	0.80	0.40	0.40	0.40	0.00	0.00	0.80	0.80	0.60	0.80	4.00	2.00	3.00	0.58	0.58	0.58
4	*Pillow-lavas, Argate*	0.80	0.40	0.40	0.40	0.20	0.20	0.00	0.80	0.60	0.20	4.00	2.20	1.80	0.52	0.52	**0.00**
5	*Volcanic rocks, Arzabaleta*	0.80	0.40	0.40	0.40	0.20	0.00	0.00	0.80	0.60	0.00	4.00	2.20	1.40	0.48	0.48	0.48
6	*Volcanic bodies, Igarate*	0.80	0.40	0.40	0.40	0.00	0.20	0.40	0.80	0.60	0.00	4.00	2.00	2.00	0.50	0.50	0.50
7	*Trachyte flows, Malzaga*	0.80	0.40	0.40	0.40	0.40	0.00	0.80	0.80	0.60	0.80	4.00	2.40	3.00	0.65	**0.30**	**0.30**
8	*Quarry, Malzaga*	0.80	0.40	0.40	0.40	0.00	0.40	0.80	0.80	0.60	0.80	4.00	2.00	3.40	0.61	0.65	0.65
9	*Fold, Urko*	0.60	0.40	0.40	0.40	0.00	0.20	0.40	0.80	0.60	0.40	4.00	1.80	2.40	0.50	0.50	0.50
10	*Folds, Eibar*	0.60	0.40	0.40	0.40	0.60	0.20	0.40	0.80	0.60	0.40	4.00	2.40	2.40	0.60	0.60	0.60
11	*Pillow-breccias, La Ascensión*	0.60	0.40	0.20	0.40	0.60	0.20	0.40	0.80	0.60	0.40	4.00	2.20	2.40	0.56	0.50	0.50
12	*Tectonic breccia, Ugarriaga*	0.80	0.40	0.20	0.40	0.20	0.20	0.40	0.80	0.60	0.40	4.00	2.00	2.40	0.53	0.53	0.53
13	*Cretaceous section, Arane*	0.80	0.40	0.20	0.40	0.00	0.20	0.40	0.80	0.60	0.40	4.00	2.00	2.40	0.53	0.53	0.53
14	*Pillow-breccias, Placencia*	0.60	0.40	0.20	0.40	0.60	0.20	0.40	0.80	0.60	0.40	4.00	2.20	2.40	0.57	0.57	0.57
15	*Outcrop, Iturbe*	0.80	0.40	0.20	0.40	0.00	0.00	0.40	0.80	0.60	0.40	4.00	1.80	2.20	0.48	0.48	0.48
	Total value														**8.27**	**7.90**	**7.38**

3.2 Geomorphosite identification and ranking

The second case study concerns the application and comparison of criteria to be used for identification and selection of geomorphosites for an inventory in the province of Cantabria (Fig. 1).

Identification and selection of geomorphosites are highly subjective tasks, necessarily based on the experience of experts and their familiarity with the area. This is a generally accepted part of the process but it is convenient to analyse the degree of coincidence between different experts, the criteria implicitly or explicitly used for selection and the degree of internal coherence of individual experts' assessment.

In the case study described identification and assessment of sites was carried out in four types of geomorphic systems: coastal, glacial, fluvial and slope. The analysis was performed separately for each one of them, in order to deal with a more homogeneous population of objects and make comparisons easier.

The initial step in the identification process was an e-mail questionnaire sent to 24 local experts, in which they were asked to indicate their personal degree of expertise on the different types of geomorphic environments as well as to provide a ranked list of at least 10 sites for each one of them (Tab. 6). An "Experts database" was elaborated with the 14 replies received. An initial classification of sites was directly derived from those replies, by simple addition of ranks assigned to each site by the different experts, the most important site having a value of 10 and the least important 1. Theoretical values would thus rank from 140 (a site identified by all experts and considered by all of them as the most important within its category) to 1 (a site named by only one expert and considered as the least important of its group). Obviously, the first case is unlikely to appear.

A second e-mail questionnaire was then sent to experts, asking them to indicate, for the two types of geomorphic environments they considered themselves more familiar with, four criteria (ranked by order of importance) they considered relevant for geomorphosite value assessment. Values between 1 (least important) and 4 (most important) were assigned and weights derived initially by simple addition, as explained before. Weights were then reduced to a 0 – 1 scale (Tabs. 7 and 8).

The following step was the establishment, by the work team, of indicators that allow the identification of three levels or degrees for each criterion (Tab. 9). Three levels were used because they can be defined quite objectively.

Value of geomorphosites was then calculated separately for each category (glacial, coastal, fluvial, slope) using the expression:

$$V_G = \sum_{i=1}^{n} c_i \times w_i$$

Where:
V_G = value of geosite

Tab. 6 - Questionnaire sent to experts.
Scheda usata per il primo questionario proposto agli esperti.

IDENTIFICATION OF GEOMORPHOSITES IN CANTABRIA

Section 1
Indicate and rank (1=max.; 4=min.) your personal degree of expertise on the different types of geomorphic environments.
COASTAL SYSTEM **(...)**
FLUVIAL SYSTEM **(...)**
GLACIAL SYSTEM **(...)**
SLOPE SYSTEM **(...)**
(Example:

COASTAL SYSTEM (2)
FLUVIAL SYSTEM (1)
GLACIAL SYSTEM (3)
SLOPE SYSTEM (4)

Section 2: Description of geomorphosites

For the geomorphic environments described above, provide a ranked list of at least 10 sites that you consider appropriate for a geomorphosite catalogue of Cantabria.

(Note: It's possible to consider less then ten sites for some geomorphic environments).

COASTAL SYSTEM:

FLUVIAL SYSTEM:

GLACIAL SYSTEM:

SLOPE SYSTEM:

Section 3: Classification of geomorphosites
For each geomorphic environment, rank geomorphosites from best (1) to worst rank (10).

RANK	COASTAL SYSTEM	FLUVIAL SYSTEM
1°		
2°		
3°		
4°		
5°		
6°		
7°		
8°		
9°		
10°		

RANK	GLACIAL SYSTEM	SLOPE SYSTEM
1°		
2°		
3°		
4°		
5°		
6°		
7°		
8°		
9°		
10°		

(Note: It's possible to add more rows or columns, if necessary.

ci = value of criterion in site (in the three-term scale)
wi = weight of criterion i
Values thus obtained are shown in Table 10.

A comparison was then made between the rank of geosites obtained directly from the initial evaluation by all experts and the one derived from the application of the expression above. Table 11 shows the results obtained for coastal sites. The agreement between both ranks is very good for sites at the top of the scale (Figs. 5, 6) and less satisfactory at lower levels, although the difference never exceeds 3 positions in the rank.

Table 12 presents a comparison between the ranks proposed by one individual expert and the same VG values of Table 11. Differences, as should be expected, are greater. More or less the same trend was observed when other individual assessments were compared with the VG rank.

Finally, in Table 13 a comparison is presented between the rank initially proposed by one expert and VG obtained using the criteria proposed by that same expert. Again, agreement is good at the top of the scale and not so good at lower levels. In this case the agreement is even better than in the other two examples, a logical result considering that we are comparing an expert with himself. However, it is clear that there is a certain inconsistency between the initial synoptic assessment and the one derived from the application of the criteria proposed by the same person. In the other words, when providing the overall assessment of sites the expert does not appear to be using exactly the same criteria he considers important for site evaluation.

4. FINAL COMMENTS

The examples above show that the analytical procedure described for the evaluation of geomorphosites provides results that are coherent with independent assessments.

Tab. 7 - Identification of SGI quality criteria.
Identificazione dei criteri di qualità per i punti d'interesse geomorfologico.

EXPERT No.						
CRITERIA	**1**	**2**	**3**	**4**	**5**	**6**
Is it inventoried?	4					
State of conservation	3	4				
Illustrates active processes	2		3	3	2	3
Size		3	2	4	4	4
Related to human issues		2		2		2
Good example of geomorph. evolution		1	4		3	
Observation conditions	1		1	1	1	1

Fig. 4 - Kárst of "Cabárceno".
Paesaggio carsico di "Cabárceno".

Fig. 5 - Dunes of Liencres.
Sistema dunare di Liencres.

Tab. 8 - Determination of weights for criteria in Table 7.

Determinazione dei pesi per i criteri della Tabella 7.

CRITERIA	**Σ**	**Weight**
Size	17	0.28
Illustrates active processes	13	0.22
State of conservation	7	0.12
Good example of geomorph. evolution	8	0.13
Related to human issues	6	0.10
Observation conditions	5	0.08
Is it inventoried?	4	0.07

That is, the "geomorphosite quality models" proposed can be used to obtain rankings of sites that coincide reasonably well with other, independent "value indicators". This is the case forinformal appreciation of sites by the general public or expenditure on site rehabilitation. Both can be considered as indicators of the value attached to those sites by society.

Results obtained with the analytical procedure also provide a reasonable coincidence with the subjective evaluation by groups of experts. The agreement is particularly good when high value sites are considered. Nevertheless, a certain degree of inconsistency has been observed when it comes to compare what an

Tab. 9 - Criteria ranks (three-term scale).

Ranghi definiti per ogni criterio selezionato (scala a tre termini).

A Size	**3**	> 1.000.000 m²
	2	10.000 – 1.000.000
	1	< 10.000 m²
B Illustrates active processes	**3**	Very active, clearly visible
	2	Moderately active
	1	Inactive or barely visible
C State of conservation	**3**	Perfectly preserved, no damage
	2	Partly damaged but main features remain
	1	Very damaged
D Good example of geomorphological evolution	**3**	Main elements for interpreting geomorphological evolution present
	2	Some features useful for interpreting geomorphological evolution
	1	Very limited or no possibility to interpret past evolution
E Related to human issues	**3**	Processes/features directly relevant for human activities
	2	Possible implication with human activities
	1	Not relevant for human activities
F Observation conditions	**3**	Complete access and visibility
	2	Some limitations for access/visibility
	1	Great difficulty for observation due to physical barriers
G Is it inventoried?	**3**	In national inventory
	2	In local/regional inventories
	1	Non - inventoried

Fig. 6 - Estuary of "San Vicente de la Barquera".

Estuario di San Vicente de la Barquera.

Tab. 10 - Value of coastal geomorphosites in Cantabria. Values in brackets correspond to criteria weights.

Valori definitivi dei punti d'interesse geomorfologico appartenenti al sistema costiero della Cantabria. I valori fra parentesi corrispondono ai pesi definiti per i criteri.

CRITERIA / **Site**	**A** (0.28)	**B** (0.22)	**C** (0.12)	**D** (0.13)	**E** (0.10)	**F** (0.08)	**G** (0.07)	**VG**
Ría de S.V. da la Barquera	3	3	2	2	2	3	2	**2.58**
Puntal de Somo	3	2	2	2	2	3	2	**2.36**
Ría de Ajo	3	3	2	1	1	1	1	**2.12**
Ría de T. Menor	3	2	2	2	1	2	2	**2.18**
Dunas de Liencres	3	3	2	3	2	3	2	**2.71**
Punta Dichoso	2	3	2	1	2	2	2	**2.09**
Plat. abrasión de La Arnía	1	3	3	3	3	3	1	**2.30**
Dunas de Oyambre	2	3	1	3	2	2	2	**2.23**
Rasas de T. Mayor	3	1	3	3	1	3	2	**2.29**
Dunas de Sonabia	1	2	3	3	1	3	1	**1.98**

Tab. 11 - Comparison between initial rank and V_G (all experts).

Comparazione tra i valori iniziali (sondaggio) ed i valori ottenuti applicando il modello di qualità (V_G).

Survey		**Site**		**Site**	$\mathbf{V_G}$
Points	**Rank**				
76	1	Dunas Liencres		Dunas Liencres	2.71
58	2	Ría S.V. Barquera		Ría S.V. Barquera	2.58
45	3	Plat. Abrasión Arnía		Puntal Somo	2.36
44	4	Rasas T. Mayor		Plat. Abrasión Arnía	2.30
32	5	Puntal Somo		Rasas T. Mayor	2.29
22	6	Ría T. Menor		Dunas Oyambre	2.23
18	7	Dunas Sonabia		Ría T. Menor	2.18
5	8	Punta Dichoso		Ría Ajo	2.12
2	9	Dunas Oyambre		Punta Dichoso	2.09
1	10	Ría Ajo		Dunas Sonabia	1.98

expert considers "should be important" (criteria) with what he "actually values as important" (direct ranking of sites). This type of inconsistency would probably be reduced if an iterative procedure, such as the DELPHI method, were used (Balkey, 1969).

In summary, the approach presented makes the procedure transparent, expressing criteria used in clear, unequivocal terms. Those criteria are represented by the values (rank, points) for the different conditions each indicator can present as well as their weights (relative importance of indicators). The "quality models" used are based on a series of simple-to-assess categorical variables. Results obtained using those models can therefore be replicated by any operator (provided the same criteria are accepted), thus significantly reducing the degree of subjectivity in the evaluation process. As the models provide results in numerical form, validation through comparison with independent assessments or indicators is greatly facilitated.

Total VSGI or other qualities such as "intrinsic quality", "potential for use" o "protection need" can thus be represented by numerical values. This numbers do not strictly represent a measure, because they correspond to dimensionless indices, but can be considered as "point values" or "positions in a rank".

Going back to the initial question presented in the title, the approached proposed provides a means to roughly "measure" some intangible geomorphosite values. Nevertheless, the procedure needs to be improved, refined and more thoroughly validated.

Tab. 12 - Comparison between initial rank (Exp. N°. 14) and V_G (all experts).
Comparazione tra i valori iniziali (sondaggio di un solo esperto, il n° 14) ed i valori ottenuti applicando il modello di qualità (V_G).

Rank Ex. N°. 14	Site		Site	V_G
1	Plat. Abrasión Arnía		Dunas Liencres	2.71
2	Dunas Liencres		Ría S.V. Barquera	2.58
3	Ría Ajo		Puntal Somo	2.36
4	Ría S.V. Barquera		Plat. Abrasión Arnía	2.30
5	Rasas T. Mayor		Rasas T. Mayor	2.29
6	Dunas Sonabia		Dunas Oyambre	2.23
7	Ría T. Menor		Ría T. Menor	2.18
8	Dunas Oyambre		Ría Ajo	2.12
9	Puntal Somo		Punta Dichoso	2.09
10	Punta Dichoso		Dunas Sonabia	1.98

Tab. 13 - Comparison between initial rank (Exp. N°. 1) and V_G (criteria of Exp. N°. 1).
Comparazione tra i valori iniziali (sondaggio di un solo esperto, il n° 1) ed i valori ottenuti applicando il modello di qualità ed i criteri definiti dal medesimo esperto (V_G).

Rank Ex. N°. 1	Site		Site	V_G(Criteria Ex. N°. 1)
1	Plat. Abrasión Arnía		Plat. Abrasión Arnía	2.8
2	Puntal de Liencres		Puntal de Liencres	2.6
3	Puntal de Santoña		Puntal de Santoña	2.3
4	Acantilados de Santoña		Puntal Somo	2.3
5	Acantilados de Oriñon		Tómbolo de Covachos	2.2
6	Depresiones de la Ensenada del Madero y Arnía		Acantilados de Santoña	2.1
7	Tómbolo de Covachos		Playa de Trengandín	2.1
8	Rasas T. Mayor		Acantilados de Oriñon	2
9	Playa de Trengandín		Rasas T. Mayor	1.9
10	Puntal Somo		Depresiones de la Ensenada del Madero y Arnía	1.6

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